REMARKS

Applicant thanks the Examiner for carefully considering this application. Please reconsider the application in view of the above amendments and the following remarks.

I. Disposition of Claims

Claims 1-3 and 5 were pending in this application. Claim 3 is cancelled and new claims 18 and 19 are added in this response. Therefore, claims 1, 2, 5, 18, and 19 are pending after the amendment. Claim 1 is independent. The remaining claims depend from claim 1.

II. Claim rejections under 35 U.S.C. § 112

A. Claims 1, 3, and 5 were rejected for not being enabled. Claim 3 has been cancelled, rendering the rejection of this claim moot. To the extent that this rejection applies to the amended claims 1 and 5, it is respectfully traversed.

As noted by the Examiner, the products of the invention may be limited by the specific process of making them. Amended claim 1 recites a reverse osmosis membrane prepared by specific processes. A product-by-process claim, which is a product claim that defines the claimed product in terms of the process by which it is made, is proper. *In re Luck*, 476 F.2d 650, 177 USPQ 523 (CCPA 1973). One of ordinary skill in the art, having benefit of the description in the specification, would be able to obtain the reverse osmosis membrane recited in amended claim 1 without undue experimentation. Claim 5 depends from claim 1

and, therefore, is patentable for at least the same reasons. Therefore, withdrawal of this rejection is respectfully requested.

B. Claims 1, 3, and 5 were rejected for being indefinite. Claim 3 has been cancelled, rendering the rejection of this claim moot. To the extent that this rejection applies to amended claims 1 and 5, it is respectfully traversed. §10b ?

Amended claim 1 recites a product by specific processes and includes a limitation that a water contact angle is no more than 45°. As shown in Table 1, on page 14 of the specification, a low water contact angle is a good indication of high salt rejection and high flux. Reverse osmosis membranes (Examples 2 and 3) prepared according to processes recited in claim 1 have significantly lower water contact angles (<45°) than that (51°) of a membrane prepared according to a prior art two-solution method (Comparative Example 1) or that (47°) of a membrane prepared according to a three-solution method, in which Solutions B and C have identical concentrations (Comparative Example 2).

By using a three-solution method, in which Solution C has a higher concentration than that of Solution B, embodiments of the invention produce membranes that have lower water contact angles (i.e., higher hydrophilicity). While not wishing to be bound by the mechanism by which this desired property is obtained, it is hypothesized that the additional Solution C at a higher concentration is able to react with the remaining amino groups that were not accessible to the polyfunctional acid halides in Solution B. As a result, the three-

solution approach as described in the present invention is able to produce more amide linkages and/or carboxylic groups (hence, higher hydrophilicity) than the prior art approach.

As amended, claim 1 recites a product produced by specific processes and includes additional limitations. Amended claim 1 is not indefinite. Claim 5 depends from claim 1 and, therefore, is patentable for at least the same reasons. Accordingly, withdrawal of this rejection is respectfully requested.

III. Rejection under 35 U.S.C § 103

A. Claims 1-3 and 5 were rejected under 35 U.S.C. § 102(b) as anticipated by or, in the alternative, under 35 U.S.C. § 103(a) as obvious over U.S. Patent No. 5,178,766 issued to Ikeda et al. ("Ikeda et al."). Claim 3 has been cancelled, rendering the rejection of this claim moot. To the extent that this rejection applies to amended claims 1 and 5, it is respectfully traversed.

The claimed invention generally relates to a composite reverse osmosis membrane having a high salt rejection and a high permeate flow rate. As recited in claim 1, a reverse osmosis membrane in accordance with the invention is prepared by a method comprising the steps of: (1) forming a layer on a porous support by coating a solution A comprising an amino compound having at least two reactive amino groups; (2) contacting the layer with a solution B comprising a polyfunctional acid halide compound; and (3) subsequently contacting the layer with a solution C comprising the polyfunctional acid halide compound at a higher

concentration than a concentration of the solution B to form the polyamide skin layer. The polyamide layer thus formed is characterized in that a contact angle between a surface of the polyamide skin layer and water is no more than 45°, sodium chloride rejection is at least 98%, and a permeate flow rate is at least 0.7 $m^3/m^2 \cdot day$ when evaluated by using feed water which has pH 6.5, 0.05 weight % of salt, an operation pressure of 5 kgf/cm^2 and a temperature of 25°C.

Advantageously, a reverse osmosis membrane in accordance with the invention is more hydrophilic (as evidenced by smaller water contact angles, < 45°) and provides high salt rejection (at least 98%) and high flow rate (at least 0.7 $m^3/m^2 \cdot day$). The flow rate is evaluated using feed water which has pH 6.5, 0.05 weight % of salt, an operation pressure of 5 kgf/cm^2 and a temperature of 25°C.

First, Ikeda et al. do not disclose a reverse osmosis membrane prepared according to the processes recited in claim 1. Consequently, it cannot anticipate claim 1. Further, because the membranes of Ikeda et al. are prepared in a different process, these membranes will not have the same properties as those of the present invention, as discussed in more detail below.

In Ikeda et al., the performance of a reverse osmosis membrane is evaluated by using a 1500 ppm NaCl solution at an operation pressure of 15 kgf/cm^2. Because the concentration of NaCl and the operational pressure are different, the flux (flow rate) and the NaCl rejection of Ikeda et al. cannot be directly compared with those of the present invention. As shown in the following, although the flux of a reverse osmosis membrane disclosed in Ikeda et al. falls within the range of the present invention, its NaCl rejection is lower than the

range of the present invention when converted to a value corresponding to the test conditions of the present invention.

In reverse osmosis, flux and salt permeation can be represented by the following equations:

$$Jv = Lp\ (\Delta P - \dot{\Delta}) \qquad (1)$$

$$Js = B\ (C2 - C3) \qquad (2)$$

where Jv is the volume flow rate (flux), Lp is the coefficient of water permeation, ΔP is the difference in pressures across the membrane, $\dot{\Delta}$ is the difference in osmotic pressures across the membrane, Js is the solute flux, B is the coefficient of solute permeation, C2 is the solute concentration at the surface of the membrane (i.e., the concentration in the feed solution), and C3 is the solute concentration in the permeate (the solution that has permeated through the membrane).

Equation (1) shows that the flux (Jv) is proportional to the difference between the differential operational pressure (which is the difference between the pressures across the membrane) and the differential osmotic pressure (which is the difference between the osmotic pressures across the membrane), i.e., $(\Delta P - \dot{\Delta})$.

When the NaCl concentration in an aqueous solution is 1500 ppm, the osmotic pressure is 1.2 kgf/cm^2, and when the NaCl concentration in a NaCl aqueous solution is 500 ppm, the osmotic pressure is 0.4 kgf/cm^2. Thus, the flux of a reverse osmosis membrane evaluated with a 500 ppm NaCl solution (which has an osmotic pressure of 0.4 kgf/cm^2) is about 0.33 (i.e., $(5 - 0.4) / (15 - 1.2)$) times the value obtained with a 1500 ppm NaCl solution (which has an osmotic

pressure of 1.2 kgf/cm^2). Therefore, a flux of 2.4 m^3/m^2·day according to Example 1 of Ikeda et al. is equivalent to 0.79 m^3/m^2·day under the test conditions of the present invention. This value is within the range of the present invention.

On the other hand, with regard to salt rejection, it is necessary to consider both solute flux and volume flux. When the salt rejection ratio is 98%, C2 − C3 ≅ C2. Therefore, the absolute amount of salt passing through the membrane is proportional to the concentration of the solute in the feed solution (C2). The salt rejection ratio can be represented by the following equation:

$$\text{rejection ratio} = (1 - (Cp / Cf)) \times 100 \qquad (3)$$

where Cf is the solute concentration in a feed solution (≅ C2) and Cp is the solute concentration in a permeate.

$C_p \approx C_3$
$C_f \approx C_2$

The salt (solute) concentration in a permeate (Cp) may be obtained by dividing the absolute amount of salt passing through the membrane by the volume of the permeate. Thus, when the operational pressure is reduced while maintaining the salt concentration in the feed solution, the salt concentration in the permeate (Cp) becomes higher because the volume of the permeate is reduced. Therefore, the rejection ratio becomes lower when the operational pressure is reduced.

Equation (3) shows that if the salt concentration is changed from 1500 ppm to 500 ppm and the flux remains the same, then there will be no change in the salt rejection ratio. However, when the flux is reduced by a factor of 3, the salt concentration in the permeate (Cp) will increase by a factor of 3, which means that Cp/Cf also increases by a factor of 3. As noted above, the volume flux

of the reverse osmosis membrane of Ikeda et al. should be reduced by a factor of 3, if it is evaluated under the test conditions of the present invention. Therefore, a salt rejection ratio of 98.1% (i.e., Cp/Cf = 1.9%) of the membrane according to Example 1 of Ikeda et al. is equivalent to a 94.3% (Cp/Cf = 5.7%) salt rejection ratio under the test conditions of the present invention. This value corresponds to the values of Comparative Examples described in the present invention and is below the range of salt rejection ratios the present invention (at least 98%), as recited in claim 1.

Thus, Ikeda et al. do not disclose or suggest the processes of preparing the reverse osmosis membranes of the present invention as recited in claim 1. Furthermore, membranes of Ikeda et al. do not have the same properties as those of the present invention recited in claim 1. Therefore, Ikeda et al. cannot anticipate or render obvious claim 1. Claims 2 and 5 depend from claim 1 and, therefore, are patentable for at least the same reasons. Accordingly, withdrawal of this rejection is respectfully requested.

other ?

Similarly, new claims 18 and 19 depend from claim 1 and are also patentable for at least the same reasons.

B. Claims 1-3and 5 were rejected under 35 U.S.C. § 102(e) as anticipated by or, in the alternative, under 35 U.S.C. § 103(a) as obvious over U.S. Patent No. 6,171,497 issued to Hirose et al. ("Hirose et al."). Claim 3 has been cancelled, rendering the rejection to this claim moot. To the extent that this rejection applies to the amend claims 2 and 5, it is respectfully traversed.

The Examiner asserts that, because a reverse osmosis membrane disclosed in Hirose et al. has the parameters similar to those of the reverse osmosis membrane according to the present invention, it is considered that the membrane of Hirose et al. has the structure similar to that of the membrane of the present invention and, thus, has a water contact angle falling within the claimed range. However, Hirose et al. do not disclose membranes prepared according to the processes recited in claim 1 of the present invention. Consequently, the structures of the membranes of Hirose et al. are distinct from those of the membranes of the present invention.

In Hirose et al., a reverse osmosis membrane having great surface roughness is treated with an oxidizing agent so that a high flux and a high rejection ratio can be obtained. In Hirose et al., the membrane has a low flux without the treatment with an oxidizing agent, as evidenced by a comparison between Example 1 and Comparative Example 2. Further, it is shown in Comparative Example 1 that a membrane having minimal surface roughness will only attain a small increase in flux even if it is treated with the oxidizing agent. Thus, to obtain a reverse osmosis membrane as claimed in Hirose et al., a membrane with a large surface area (due to great roughness) is treated with an oxidizing agent to further degrade a portion of the surface thereof. Such a reverse osmosis membrane can achieve a high rejection ratio for a charged salt due to repulsion of charged particles. However, it does not have a high rejection ratio for a non-charged solute such as organic substances. This is because the non-charged

solute can pass through the membrane from the portion degraded by the oxidizing agent on the surface of the membrane.

In contrast, to obtain a reverse osmosis membrane as claimed in the present invention, a membrane is formed and then brought into contact with a solution containing an acid halide at a higher concentration. The treatment with the additional acid halide solution increases the acid halide concentration on the surface of the membrane. As a result, more amide and/or carboxylic acid groups are formed on the surface of the membrane, leading to an increased hydrophilicity of the membrane and a high flux. Unlike the method disclosed in Hirose et al., the method of forming the membrane according to the present invention does not degrade or cause a defect on the surface of the membrane. Therefore, the reverse osmosis membrane thus-obtained can exhibit a high rejection ratio not only for charged salts, but also for non-charged molecules.

Because Hirose et al. do not teach or suggest reverse osmosis membranes prepared by the processes recited in claim 1, membranes of Hirose et al. have different properties from those of the present invention. For these reasons, Hirose et al. cannot anticipate or render claim 1 obvious. Claims 2 and 5 depend from claim 1 and, therefore, are patentable for at least the same reasons. Accordingly, withdrawal of this rejection is respectfully requested.

Similarly, new claims 18 and 19 depend from claim 1 and are also patentable for at least the same reasons.

IV. Concluding Remarks

Applicant believes this reply to be fully responsive to all outstanding issues and place this application in condition for allowance. If this belief is incorrect, or other issues arise, do not hesitate to contact the undersigned or his associates at the telephone number listed below. Please apply any charges not covered, or any credits, to Deposit Account 50-0591 (Reference Number 04558.039001).

Respectfully submitted,

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